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GROWTH, CHLOROPHYLL CONTENT AND COMBINED OUTPUT VALUE IN EGGPLANT/GARLIC RELAY INTERCROPPING SYSTEMS

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Abstract

A plastic tunnel experiment was conducted to investigate the effect of eggplant/garlic relay intercropping on the eggplant growth, chlorophyll content and combined output value in 2011 and 2012. The experimental design was randomized block with three replications consisting of eggplant monoculture (CK), eggplant relay intercropping with normal garlic (NG) and eggplant relay intercropping with green garlic (GG). It is showed that the eggplant stem in 2011 was first thicker then thinner in CK than NG, and it was always thicker in CK than GG; the plant height and stem diameter were both higher in relay intercropping treatments than CK in 2012. The chlorophyll content and chlorophyll a/b ratio were lower in NG compared with CK in most cases. In 2011, the eggplant yield and combined output value in GG were lower than CK, but in 2012, they were higher and the difference of combined output value between GG and CK was significant; for NG, they were always promoted both in 2011 and 2012. Different results between 2011 and 2012 may be due to the different time of green garlic uprooted in the spring. It is proved that uprooting green garlic before eggplant transplanting in 2012 was better to eggplant growth than uprooting them after eggplant transplanting in 2011. The conclusions are drawn that relay intercropping with normal or green garlic can improve the eggplant growth, increase the yield and the combined output value. As a result, eggplant/garlic relay intercropping systems may contribute to sustainable production of eggplant.

Key words: Chlorophyll, Eggplant/Garlic, Intercropping

Introduction

Eggplant (*Solanum melongena* L.), as an important vegetable crop because of its nice flavor and nutritious and medicinal value, is cultivated worldwide (Frary *et al.*, 2007); China is one of the eggplant top producer in recent decades. As a result of the decreasing farmland and increasing human population, coupled with the economic interest for high yield, eggplant continuous cropping in plastic tunnel is fairly common in China. Among agronomic practices, continuous cropping is defined as growing the same crop year after year in the same field (Nafziger, 2009). However, there are apparent obstacles as eggplant continuous cropping. Continuous cropping increases autotoxins which hinder eggplant growth; decreases resistance to cold, heat and disease; weaken growth potential; slows development; and reduces yield and quality.

At present, many agricultural measures are adopted to solve continuous cropping obstacles. The diversification of crop systems by increasing the number of cultivated species in the same or nearby areas has been proposed as a solution of continuous cropping in modern agriculture (Gomes *et al.*, 2007). Relay intercropping, a traditional cultivation method in China, means that different crops are planted at different times in the same field, and both (or all) crops spend at least part of their season growing together in the field (Nafziger, 2009). A relay intercropping system make contributions to crop production by its effective utilization of resources, as compared to a monoculture system (Li *et al.*, 1999; Li *et al.*, 2001; Zhang & Li, 2003). Available resources, such as light, water and nutrients can be fully absorbed and converted to crop biomass by the intercrop components as a result of different competitive ability for growth (Lithourgidis *et al.*, 2011).

It is shown that different intercropping combinations have different effects on the morphology of the main crop. Singh *et al.* (2000) found that the growth parameters of sunflower (*Helianthus annuus* L.) were inferior under intercropping systems particularly with 1:2 row planting geometry than sole crop during the second year. Besides, peas (*Pisum sativum* L.) caused more competitive effects on growth of sunflower than linseed (*Linum usitatissimum* L.) among the intercrops. As a critical substance, chlorophyll fulfils the requirements for photosynthesis which is the prerequisite of all life on earth (Mauzerall, 1976). The chlorophyll of wheat (*Triticum aestivumLinn* L.) and maize (*Zea mays* L.) leaves were enhanced 8.88% and 4.07%, respectively in relay intercropping systems compared with when they were planted singly (Niu *et al.*, 2009). The more efficient utilization of growth resources in intercropping systems may lead to yield advantages and increased stability compared to sole cropping (Knörzer *et al.*, 2009). Intercropping is one of the most practical techniques to increase crop yields (Li *et al.*, 2006) and improve land-use efficiency (Banik *et al.*, 2006; Gao *et al.*, 2010). The intercropping of alfalfa (*Medicago sativa* L.) with corn (*Zea mays* L.) had yield advantages compared to alfalfa or corn monoculture (Zhang *et al.*, 2011). Anil *et al.* (1998) and Misra *et al.* (2006) also documented cereals or soybean (*Glycine max*) yield advantages compared with the corresponding monocultures. The yield promoting effects had also been observed in many other intercropping systems, such as groundnut (*Arachis hypogaea* L.)/maize (Sharma & Behera, 2009) and wheat/cotton (*Gossypium* spp.) systems (Zhang *et al.*, 2007), etc.

In a series of studies on many aspects on mixed cropping systems, wheat/bean or maize (Li *et al.*, 2005), alfalfa/corn (Zhang *et al.*, 2011) intercropping systems, intercropping systems based on cauliflower (*Brassica oleracea* L. var. *botrytis*) (Yildirim & Guvenc, 2005), and wheat/cotton relay intercropping system (Zhang *et al.*, 2007) etc. have been studied, yet information on growth and yield response have not been given for eggplant relay intercropping with garlic (*Allium Sativum* L.). Garlic is a food spice that is used widely throughout the world. It is also commonly used as a good preceding crop (Kumar & Berwal, 1998; Han *et al.*, 2012) and companion crop because it can significantly increase the level of nutritional elements such as nitrogen, phosphorus and potassium in cucumber (*Cucumis sativus* L.) when intercropped with green garlic (Xiao *et al*., 2013). Some studies have reported that garlic can also prevent insect attack on potato (*Solanum tuberosum* L.) (Mogahed, 2003) and weed invasion on beet (*Beta vulgaris* L.) (Mueller *et al*., 1998) in intercropping systems.

Only few garlic intercropping studies, such as intercropping cucumber (Xiao *et al*., 2012) and pepper (*Capsicum annuum* L.) (Ahmad *et al*., 2013) have investigated the soil physicochemical properties or the income of intercropping system. Data on change of eggplant physiology and the combined output value of relay intercropping with garlic is still unknown. This study was under plastic tunnel to evaluate the effects of relay intercropping eggplant with normal garlic or green garlic on the growth and leaf chlorophyll content of eggplant, together with yield and combined output value to explore the advantages of eggplant/garlic relay intercropping systems.

Materials and Methods

Experimental site description: The experiment was carried out from September 2010 to November 2012 under plastic tunnel at the Horticultural Experimental Station (34°17' N, 108°04' E) in Northwest A&F University, Yangling, Shaanxi Province, China. The annual average temperature is 12.9°C and the frost-free period is over 200 days.

The soil is a brown loamy, alkaline Orthic Anthrosol. The pH value of soil is 7.8 (1soil:1water) and it contains 27.0 g organic matter, 1.4 g total nitrogen (N), 1.0 g total phosphorus (P), and 14.3 g total potassium (K) per kilogram of dry soil. The ammonium N concentration is 57.2 $mg\cdot kg^{-1}$, and available P 57.7 $mg\cdot kg^{-1}$, exchangeable K 224.0 $mg\cdot kg^{-1}$ for 0-20 cm soil layer before eggplant transplanting.

Experimental design: Eggplant was continuously relay intercropped with garlic. A randomized block design was used consisting of three treatments and replicated thrice (Fig. 1): eggplant monoculture (CK), eggplant relay intercropping with normal garlic (NG, sow garlic cloves of cv. G110 and then harvest bulbs in next April), and eggplant relay intercropping with green garlic (GG, sow whole bulb of cv. G064 and then reap green garlic sprouts three or four times each year).

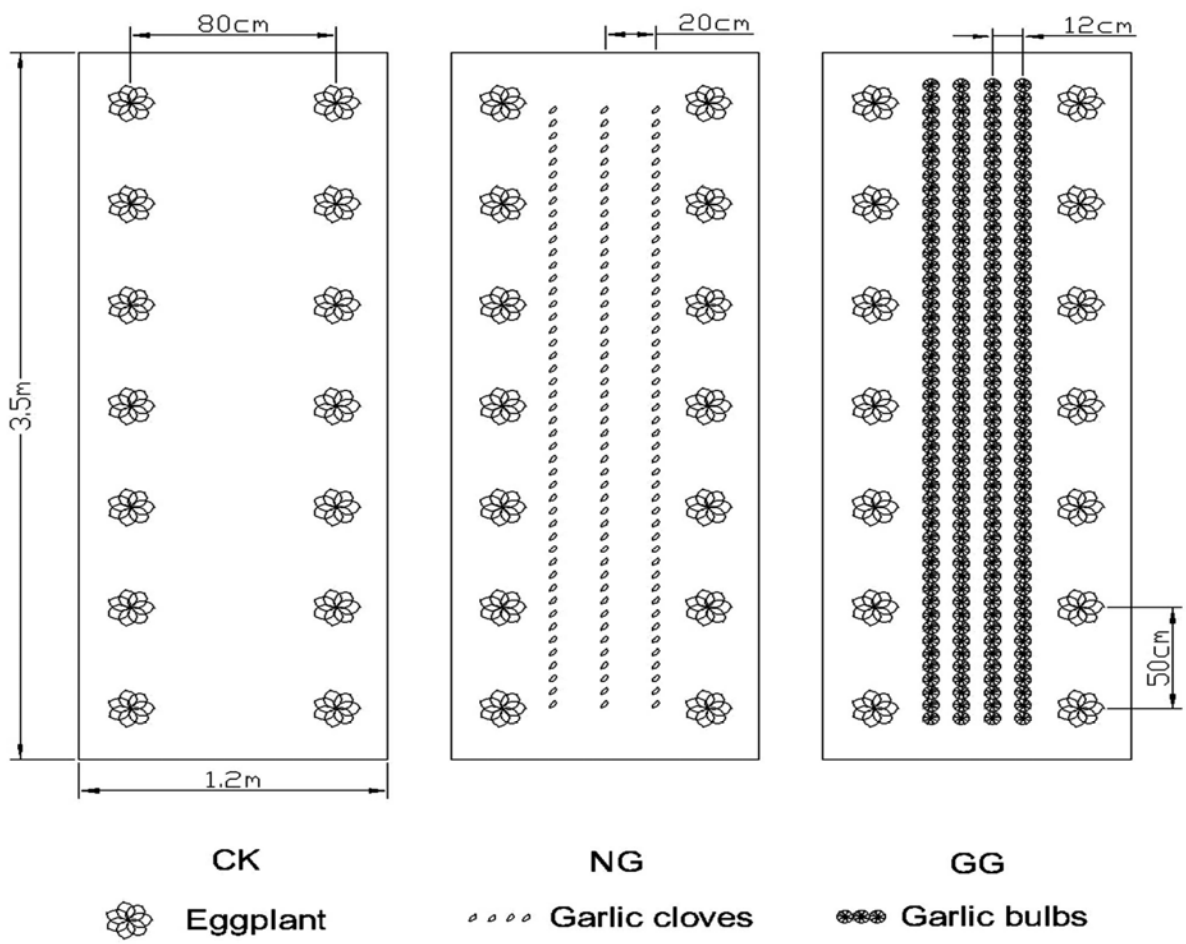

Fig. 1. The schematic diagram of three cropping systems
CK: eggplant continuous monoculture; NG: eggplant relay intercropping with normal garlic; GG: eggplant relay intercropping with green garlic

There were two beds per replication for the three treatments. Each bed size was 1.2 m × 3.5 m. Eggplants in all treatments were spaced 50 cm for plant space and 80 cm for row space in each bed, two rows per bed and 7 plants per row. In relay intercropping treatments, three rows normal garlic (20 cm for row space and 6 cm for plant space, 141 cloves for each bed) and four rows green garlic (12 cm for row space and side by side in each row, 8.5 kg bulbs for each bed) were planted in the middle of each bed between the two eggplant rows, respectively. Eggplants were grown from 2010. They were transplanted respectively on 19 March, 2010, 22 March, 2011 and 24 March, 2012, and uprooted on 25 November in the three years. In 2010, seed bulbs and cloves were planted on 15 September, and three treatments were applied. Then in 2011 and 2012, garlic cloves of uniform size were manually planted between the eggplant rows on 15 September in NG treatment; in GG treatment, garlic bulbs were planted directly by hand on 1 August and 20 July respectively in 2011 and 2012. Parameters were measured in 2011 and 2012.

Every year before eggplants were transplanted, experimental plots were manually plowed, and fertilized with 1.5 kg "PengDiXin" (containing organic matter ≥30%, N+P_2O+K_2O ≥4%, humic acid ≥20%, trace element ≥2%, organic sylvite ≥5%, Zhengzhou Jinzheng Bio-chemical Co., LTD, Henan Province, China), 0.15 kg double superphosphate (total P ≥46%, available P ≥44%) and 0.15 kg compound fertilizer "SaKeFu" (containing diammonium hydrogen phosphate ≥45%, total N ≥15%, available P ≥15%, available K ≥15%, Sino-Arab Chemical Fertilizers Co., LTD, Hebei Province, China) per bed as base fertilizer. Then the same amount of topdressing (called "JinBa" containing humic acid ≥3%, trace element ≥6%, N+K_2O ≥18% and phosphate and K-solubilizing agent ≥5%, RiShengJiuFeng Biotechnology Co., LTD, Beijing, China) and irrigation were applied to each bed regularly following local farmer's normal conventions according to the plant growth condition in the eggplant-only period and relay intercropping period. Only irrigation was applied when normal garlic or green garlic needed during their only-period.

At the growth stages, eggplant was double pole trained and the branches were hung up by nylon ropes, and then triced on the iron wire upon the eggplant. Other farming managements were followed as local convention.

Measurement

Eggplant growth index: The eggplant morphological parameters were measured on 11 April, 28 April, 18 May, 20 June, 30 August, 20 September, and 20 October in 2011 and on the 17th of every month from April to October in 2012 for characterizing the plant growth. Plant height was measured using tape (0.1 cm) and the stem diameter using electronic vernier caliper (0.01 mm). The plant height is the vertical distance from the ground to the highest leaf tip under natural conditions; stem diameter is the thickest part in the middle of the internode above the cotyledons, as characterized by Li and Zhu (2006) with some modification.

Eggplant leaf chlorophyll content: Leaf samples were collected randomly from the middle-upper part of the eggplants at 10:00 am on each sampling date; one fully expanded leaf per plant and six plants per treatment. Healthy leaves were cut off from the petioles. The first sampling date was 28/17 April (36/24 days after eggplant transplanting) in 2011 and 2012, respectively. Then samples were taken on 21 June/17 June (eggplant blooming and fruit-bearing period after all garlic harvested), 25 July/15 July (5 days before planting green garlic), 30 August/10 September (15/5 days before planting normal garlic), 10 October/21 October (eggplant/garlic co-growth period and eggplant late growth stage).

Once the eggplant leaves were cut off, they were put in a plastic bag, and then tiled among crushed ice to be taken to the lab. The leaf surface was washed by tap water and distilled water subsequently, then wipe-dried gently using absorbent paper. Afterwards, all leaves were cut into small pieces (excluding thick veins) and some were randomly selected to cut into smaller pieces (about 2 mm by 2 mm). 0.100 g mixed leaf pieces was put into 20 mL extracting agent (95% aqueous solution with acetone and ethanol at the volume ratio of 2:1) for chlorophyll extraction using the modified method of Yang (2002). After extraction under dark condition for 24 h at room temperature, the chlorophyll contents and chl a/b ratios were determined by UV-Vis spectrophotometry at 645 nm and 663 nm and calculated according to the formula of Arnon (1949). Determinations were performed in triplicate, with values reported as means of each treatment.

Eggplant yield and combined output value: Marketable eggplant fruits were harvested at every ripening time. In GG treatment, once the green garlic grew up to 30-40 cm high, they were cut off from above of the garlic bulb—three or four times within three months after the garlic bulbs planted and uprooted in the next spring. In 2011, green garlic was uprooted on 15 April. But it was found that the thick green garlic blocked sunlight from reaching small eggplant seedlings, accordingly affected eggplant growth and development, so in 2012, they were uprooted before eggplant transplanted on 22 March. In NG treatment, enlarged garlic bulbs were harvested manually in the next mid-April in both years. The entire yield from each plot of each treatment were tallied, analyzed, and presented as average in kilogram per hectare ($kg \cdot ha^{-1}$).

Combined output value was analyzed to assess economic feasibility in different treatments. Cost of land use, buildings, materials, and labor cost of eggplant planting, management and harvest were assumed to be the same for all systems. Materials expense items included eggplants seeds, tools, and fertilizers, etc. These expenses were not calculated in the combined output value for all treatments. Variable costs of garlic inputs and labor cost of garlic planting, management, and harvest were determined according to the market price. The cost of garlic cloves or bulbs for planting (RMB 4·kg^{-1}) (Ren Min Bi Yuan) in NG or GG treatment was RMB 3942.9/3428.6·ha^{-1} or RMB 80761.9/80952.4·ha^{-1} respectively in 2011/2012. The labor cost of garlic in each year was RMB 6000·ha^{-1} and RMB 7500·ha^{-1} for NG and GG treatment. Eggplant gross income meant eggplant yield multiplied by the eggplant unit price (RMB 4·kg^{-1}) in different treatments. Garlic gross income meant garlic bulbs harvested in NG treatment or green garlic harvested in GG treatment multiplied by garlic product unit price (RMB 8·kg^{-1}). Combined output value was calculated by subtracting garlic-related input from both eggplant and garlic gross income for each treatment.

Statistical analyses: The data of plant height, stem diameter, leaf chlorophyll content, chl a/b ratio, and combined output value of different cropping systems were statistically analyzed applying ANOVA procedure of PASW Statistics 18.0 software (IBM, Armonk, New York, USA). Means were compared with Duncan's multiple range tests at $p< 0.05$ level.

Results

Plant height of eggplant: The effects of relay intercropping with garlic and monoculture on eggplant height were shown in Fig. 2. The eggplant grew fast from May to August, slowed down later and then nearly stopped in late October in both years. In 2011, the plant height in CK and NG had no regularity between each other. For GG, the plant was always a little shorter than that in CK except on 11 April, 2011. In 2012, the plant height was slightly increased by relay intercropping with normal garlic and green garlic on most sampling dates beyond that on 17 April.

Stem diameter of eggplant: Stem diameter increased over time with the plant height in both years (Fig. 3). In 2011, the plant stem in NG was a little thinner than that in CK from April to June, but an opposite result was shown from August to October. On 28 April and 18 May when eggplant were in the early growing periods, the differences between CK and NG were significant. For GG, the stem was thinner than CK in all growth stages. In 2012, the stems both in NG and GG were slightly thicker than that in CK in almost all sampling dates.

Chlorophyll content in eggplant leaves: The chlorophyll content first increased then decreased in both 2011 and 2012 (Fig. 4). On 28 April, 2011, shortly after the garlic bulbs and green garlic were uprooted, the chlorophyll content of eggplants in both NG and GG was higher than CK and the difference between GG and CK was significant. However on 21 June, the eggplant full fruit period, the chlorophyll content of eggplants in GG was significantly lower than CK instead. It reached the highest level for all three treatments on 25 July, 5 days before the green garlic planted again and the most vigorous growing period of eggplant. But on 30 August before normal garlic planted again, they all reduced and the value of NG was significantly lower than the other two treatments. On 10 October, when normal garlic and green garlic took root and came into leaf again, the value of NG and GG was again higher than CK and the difference between GG and CK was significant.

In 2012, the third year of eggplant cultivation, the chlorophyll content of eggplants in NG treatment was significantly lower than that in CK on 17 April when the garlic bulbs had just harvested. Beyond that, there were no significant differences between NG and CK. As to GG treatment, only on 10 October, in the relay intercropping period, the chlorophyll content of eggplant was significantly higher than that in CK. Significant differences between them were not observed on other sampling dates. No treatment produced consistently higher or lower chlorophyll content across dates or years.

Chl a/b ratio in eggplant leaves: The change of chl a/b ratio was shown in Fig. 5. In 2011, the chl a/b ratio in CK and GG increased from April to June then kept decreasing; but in NG, it kept increasing from April to July then decreased. The chl a/b in CK was significantly higher than that in NG on 21 June and in GG on 10 October. Beyond that, there were no significant differences among the three treatments. Then in 2012, the change rule of chl a/b showed a "W" shape. On 17 April, the value of GG was significantly higher than CK. In late growth stage (10 September and 21 October), it was significantly lower in GG than that in CK. But for NG, it was lower than CK on most sampling dates which was similar to chlorophyll content; especially on 15 July in eggplant vigorous growing stage as well as on 21 October after the garlic leaves grew out, it was significantly lower than CK.

Eggplant yield and combined output value: The eggplant yield and the combined output value of the three treatments in 2011 and 2012 were shown in Table 1. The results indicated that in 2011, the eggplant yield was slightly enhanced by relay intercropping with normal garlic, but decreased a little by relay intercropping with green garlic. Then in the third continuous cropping year in 2012, the eggplant yield in NG and GG was respectively 6.3% and 7.8% higher than CK. In addition to the higher income brought by higher eggplant yield in NG and GG compared with CK, the income of garlic products was also an economic source to improve the land profits in relay intercropping treatments. In 2011, the combined output value per hectare of NG (RMB 19820.6 yuan) was 5.0% higher than CK, and in 2012 it was 7.3% (RMB 20738.1 yuan) higher than CK. However for GG treatment, the combined output value per hectare (RMB 23641.3 yuan) was 6.0% lower than CK in 2011, but 45.8% (RMB 130341.3 yuan) higher than CK in 2012 and the difference between GG and CK was significant. In short, relay intercropping with normal garlic slightly improved the yield of eggplant and the land benefit in both years; yet they were reduced a little by relay intercropping with green garlic in 2011, but significantly increased in 2012.

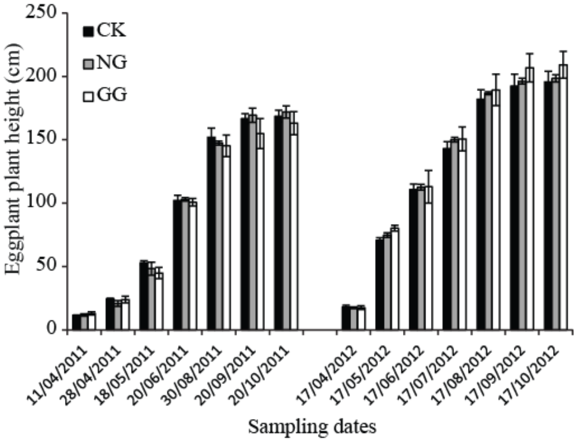

Fig. 2. Eggplant plant height of different relay intercropping patterns in 2011 and 2012
Error bars present as the standard error of the mean
CK: eggplant continuous monoculture; NG: eggplant relay intercropping with normal garlic; GG: eggplant relay intercropping with green garlic

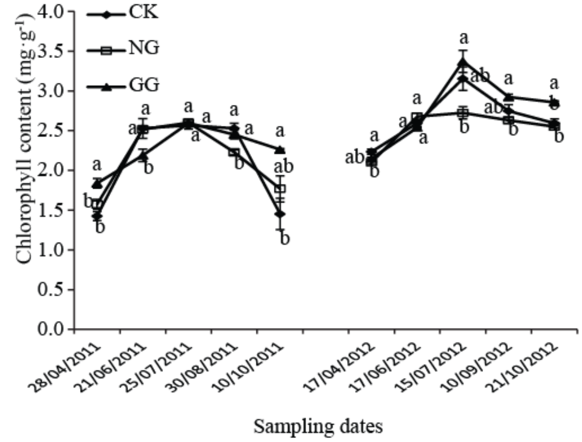

Fig. 4. Chlorophyll (chl) content in eggplant leaves of different relay intercropping patterns in 2011 and 2012
Error bars present as the standard error of the mean. The letters a, b indicate significant differences at $p< 0.05$ (ANOVA and Duncan's multiple range test, n=3)
CK: eggplant continuous monoculture; NG: eggplant relay intercropping with normal garlic; GG: eggplant relay intercropping with green garlic

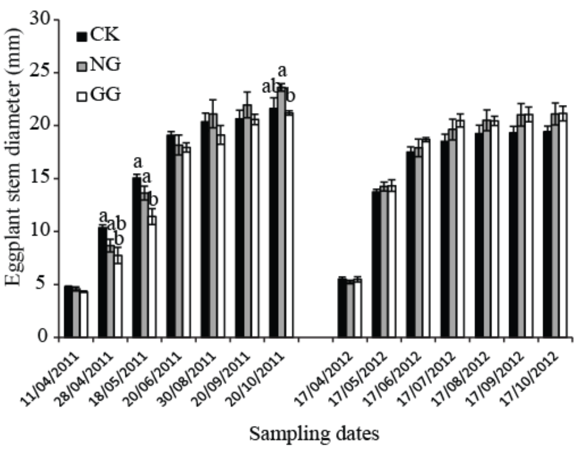

Fig. 3. Eggplant stem diameter in the first internode of different relay intercropping patterns in 2011 and 2012
Error bars present as the standard error of the mean. The letters a, b indicate significant differences at $p< 0.05$ (ANOVA and Duncan's multiple range test, n=3)
CK: eggplant continuous monoculture; NG: eggplant relay intercropping with normal garlic; GG: eggplant relay intercropping with green garlic

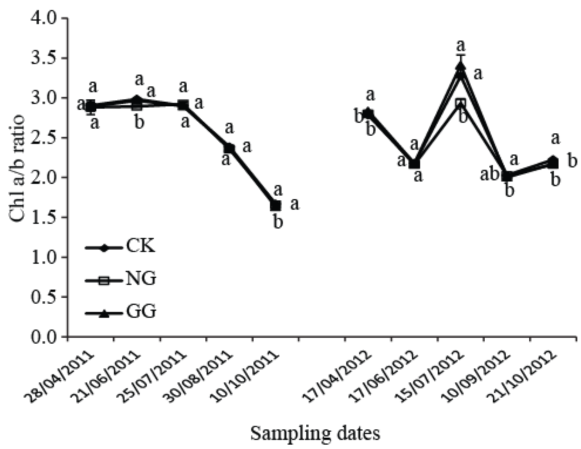

Fig. 5. Chlorophyll a/b (chl a/b) ratio in eggplant leaves of different relay intercropping patterns in 2011 and 2012
Error bars present as the standard error of the mean. The letters a, b indicate significant differences at $p< 0.05$ (ANOVA and Duncan's multiple range test, n=3)
CK: eggplant continuous monoculture; NG: eggplant relay intercropping with normal garlic; GG: eggplant relay intercropping with green garlic

Discussion

As a classical agricultural practice, the advantages of intercropping compared to monoculture are due to interactions between intercrop components, caused by differences of the competitive ability for environmental sources (Wit, 1960; Trenbath, 1976). Plants are usually able to adjust their growth and morphology in response to different growth conditions (Waller, 1986; Canham, 1988; Poorter & Werger, 1999; Valladares, 1999). Height growth plays an important role in morphological acclimation to light competition (Lanner, 1985), with plants tending to allocate more photosynthate to height than diameter growth, which results in increasing stem slenderness (Benomar *et al.*, 2012). Nonetheless, stem diameter is also an important index reflecting plant growth. It was shown from the results of plant height and stem diameter that the eggplant grew fast from May to August and later slowly then the eggplant growth entered the aging phase in both years' experiment. On April 28 and May 18, 2011, the stem in GG was significantly thinner than CK. Probably, the thick green garlic leaves in GG blocked sunlight from reaching eggplant seedlings until the green garlic was uprooted, and this negative effect continued until May 18,

2011. Just as Khan *et al.* (2000) found, stem diameter was significantly lower at the highest shade level. On the other hand, the nutrient competition between eggplant seedlings and lush green garlic under the same amount fertilizer for all treatments is also an important reason. However, similar situation did not occur in the same period in 2012 as the green garlic was uprooted before eggplant transplanting. In this way, the green garlic would not affect the eggplant growth; instead, eggplant growth was promoted by the residue of green garlic.

Most plants require light not only for photosynthesis but also for the chlorophyll development (Aronoff, 1950). Chlorophyll is vital for photosynthesis, which allows plants to absorb energy from light. The degradation of chlorophyll is of central importance to plant development and plant response to the environment (Pilkington *et al.*, 2012). Barnett (1989) found that chlorophyll concentrations tended to be higher under lower light levels, and vice versa. On 28 April shortly after the garlic was harvested and 10 October during the relay intercropping period in 2011, the chlorophyll content of eggplant in NG and GG was higher than monoculture ones, which is probably that relay intercropping with garlic stimulated the formation of chlorophyll in eggplant leaf. In 2012, both the chlorophyll content and the chl a/b ratio in NG was lower than CK in most cases. On 17 April, 2012, the chl a/b ratio in GG was significantly higher than CK, yet the chlorophyll content was lower, might because green garlic with dense leaves blocked the light on eggplant seedlings, affected the eggplant photosynthesis, thus caused the light-harvesting pigment chl b reduced (data not shown). Conversely, at the eggplant late growth stage in 2012 (10 September and 21 October), the chl a/b ratio in GG was significantly lower than that in CK, yet the chlorophyll content was higher, meaning a relative increase of light-harvesting amount after relay intercropping with green garlic sequentially made the eggplant capture more light to promote growth.

In agricultural production, yield and the land output are highly important to farmers. Growth conditions are very significant to yield (Khan *et al.*, 2010; Tabrizi *et al.*, 2011). It was recorded in our study that the eggplant growth vigor in GG was weaker compared with CK in 2011. In the meantime, the eggplant yield in GG was also lower than CK. The weaker growth potential in GG might lead to a weaker reproduction growth thus affecting the yield. However in 2012, stronger eggplant and higher yield in NG and GG were observed. Rusinamhodzi *et al.* (2006) found a higher productivity in the cotton/cowpea (*Vigna unguiculata* L. Walp) intercropping system. Bedoussac and Justes (2010) found that durum wheat-winter pea intercropping could improve yield. Also Li *et al.* (2011) found that strip intercropping of maize with faba bean (*Vicia faba* L.), wheat and barley (*Hordeum vulgare* L.) increased yield. These studies were partially in accordance with our results. In our study, in the second year of eggplant continuous cropping in 2011, the eggplant yield was increased when relay intercropped with normal garlic. It is reasonable to assume that relay intercropping with normal garlic might play a driving role to eggplant growth. But, relay intercropping with green garlic reduced eggplant yield in 2011. Similarly, Nassab *et al.* (2011) thought maize and sunflower produced less yield in intercrops compared to monocrops. The result also agreed with findings of Lesoing and Francis (1999) in corn-soybean and sorghum (*Sorghum bicolor* (L.) Moench)-soybean intercrops that the sole crop components yielded higher than the corresponding intercrops. And Mbah *et al.* (2007) reported that intercropping reduced the yields of soybean and maize compared with their sole crops. These results may due to the inappropriate intercropping combination, improper cultivated density or other reasons. In our study, the nutrients and water competition and garlic shading effect on eggplant in the eggplant seedlings/green garlic co-growth stage in 2011 affected late growth of eggplant. Nonetheless in 2012, the green garlic was timely cut before the eggplant was transplanted on 22 March, therefore those negative effects did not exist and the green garlic even help increase eggplant growth and yield. In addition to higher yield of eggplant, the garlic bulb harvested in NG treatment and green garlic harvested in GG treatment also increased the output value in unit and enhance land-use utility greatly.

Table 1. Eggplant yield and combined output value of different relay intercropping patterns in the second and third cropping year (2011 and 2012).

Treatment	Year	Eggplant yield	Garlic bulb/green garlic yield	Eggplant gross income	Garlic bulb or green garlic gross income	All garlic-related costs	Combined output value
CK	2011	99610.7	0.0	398442.9	0.0	0.0	398442.9 a
	2012	71140.9	0.0	284563.5	0.0	0.0	284563.5 b
NG	2011	102448.4	2301.6	409793.7	18412.7	9942.9	418263.5 a
	2012	75595.2	1543.7	302381.0	12349.2	9428.6	305301.6 b
GG	2011	81281.7	17242.1	325127.0	137936.5	88261.9	374801.6 a
	2012	76692.5	24573.4	306769.8	196587.3	88452.4	414904.8 a
Remarks		$kg{\cdot}ha^{-1}$	$kg{\cdot}ha^{-1}$	$RMB{\cdot}ha^{-1}$ ($4{\cdot}kg^{-1}$)	$RMB{\cdot}ha^{-1}$ ($8{\cdot}kg^{-1}$)	$RMB{\cdot}ha^{-1}$	$RMB{\cdot}ha^{-1}$

CK: eggplant monoculture; NG: eggplant relay intercropping with normal garlic; GG: eggplant relay intercropping with green garlic
The letters a, b indicate significant differences at $p< 0.05$ (ANOVA and Duncan's multiple range test, n=3)
The "$kg{\cdot}ha^{-1}$" means kilograms per hectare; "RMB" means Ren Min Bi Yuan
Remark of "All garlic-related costs": $RMB{\cdot}ha^{-1}$ (cost of seed normal garlic and seed green Garlic (RMB $4{\cdot}kg^{-1}$) was 3942.9/3428.6 and 80761.9/80952.4 respectively in 2011/2012; cost of garlic processing, growing and harvesting was RMB $6000{\cdot}ha^{-1}$ and RMB $7500{\cdot}ha^{-1}$ for NG and GG treatment both in 2011 and 2012)

Conclusions

Continuous cropping obstacle is one of the urgent problems in sustainable agricultural production. Plant height and stem diameter of eggplant increased and the chlorophyll in eggplant leaves was enhanced under relay intercropping with garlic compared to eggplant monoculture to maintain eggplant growth potential. Eggplant yield and combined output value of eggplant/garlic relay intercropping systems were also promoted to ensure the eggplant sustainable production. Taken together, relay intercropping eggplant with garlic could be considered as a good sustainable planting pattern worth popularizing.

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